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(54) TERMINAL DEVICE, A BASE STATION DEVICE, A COMMUNICATION METHOD, AND AN INTEGRATED CIRCUIT FOR PROCESSING DEMODULATION REFERENCE SIGNALS

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CPC H04B 15/00; H04L 1/0057

See application file for complete search history.

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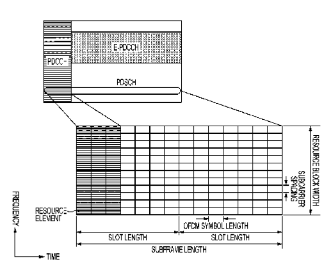
(57) **ABSTRACT**

There are provided a terminal device, a base station device, a communication method, an integrated circuit, and a wireless communication system that enable a base station device and a terminal device to determine parameters related to uplink signals or uplink reference signals and to perform efficient communication. In a terminal device that transmits a demodulation reference signal, a sequence group number is determined on the basis of a value of a parameter configured by a higher layer in a case where a transmission on a physical uplink shared channel is performed in accordance with a downlink control information format to which CRC parity bits scrambled by a C-RNTI are attached, which is transmitted on an enhanced physical downlink control channel, and the sequence group number is determined on the basis of a physical layer cell identity in a case where a transmission on the physical uplink shared channel is performed in accordance with a downlink control information format to which CRC parity bits scrambled by a Temporary C-RNTI are attached, which is transmitted on a physical downlink control channel.

14 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H04L 5/00	(2006.01)
H04L 1/00	(2006.01)
H04W 24/02	(2009.01)
H04W 74/08	(2009.01)
H04L 1/18	(2006.01)

(52) **U.S. Cl.**
CPC ***H04L 5/0048*** (2013.01); ***H04W 24/02*** (2013.01); *H04L 1/1812* (2013.01); *H04L 5/001* (2013.01); *H04L 5/0035* (2013.01); *H04L 5/0053* (2013.01); *H04L 5/0073* (2013.01); *H04W 74/0833* (2013.01)

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FIG. 1

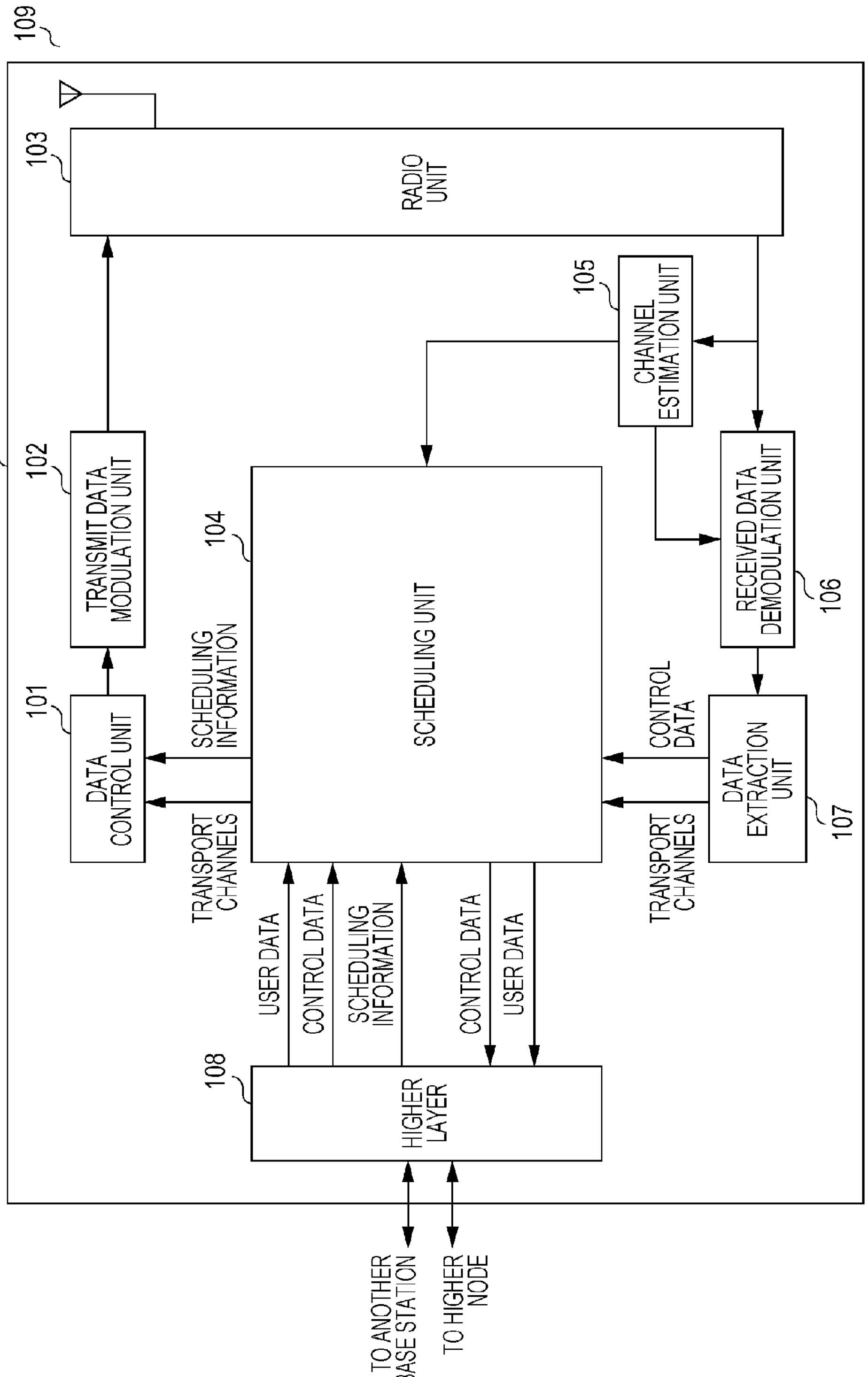

109
100
103
RADIO UNIT
105
CHANNEL ESTIMATION UNIT
102
TRANSMIT DATA MODULATION UNIT
104
SCHEDULING UNIT
106
RECEIVED DATA DEMODULATION UNIT
101
DATA CONTROL UNIT
SCHEDULING INFORMATION
TRANSPORT CHANNELS
CONTROL DATA
TRANSPORT CHANNELS
107
DATA EXTRACTION UNIT
USER DATA
CONTROL DATA
SCHEDULING INFORMATION
CONTROL DATA
USER DATA
108
HIGHER LAYER
TO ANOTHER BASE STATION
TO HIGHER NODE

FIG. 2

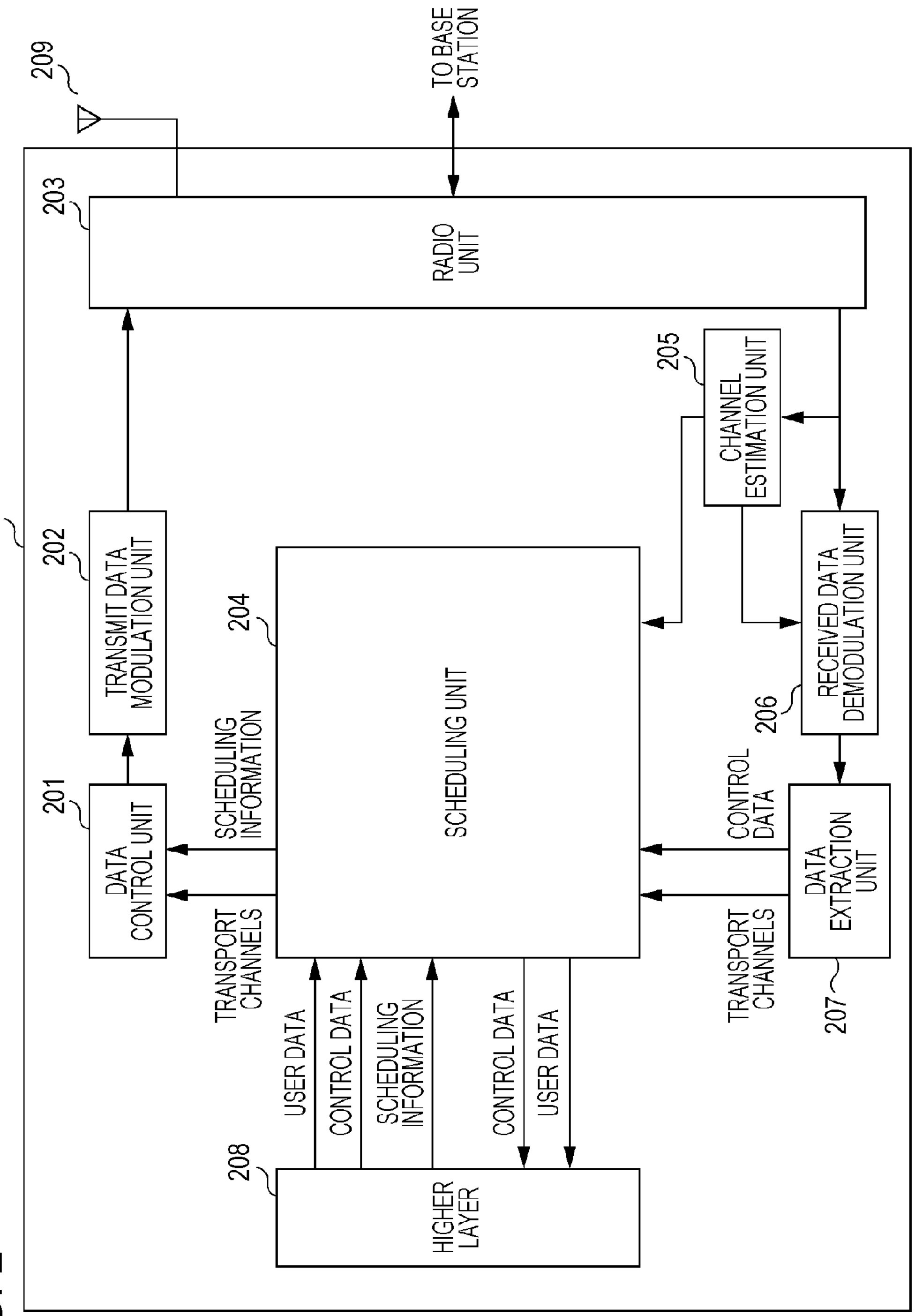

200
209
TO BASE STATION
203
RADIO UNIT
202
TRANSMIT DATA MODULATION UNIT
201
DATA CONTROL UNIT
205
CHANNEL ESTIMATION UNIT
204
SCHEDULING UNIT
206
RECEIVED DATA DEMODULATION UNIT
207
DATA EXTRACTION UNIT
SCHEDULING INFORMATION
TRANSPORT CHANNELS
CONTROL DATA
TRANSPORT CHANNELS
USER DATA
CONTROL DATA
SCHEDULING INFORMATION
CONTROL DATA
USER DATA
208
HIGHER LAYER

FIG. 3

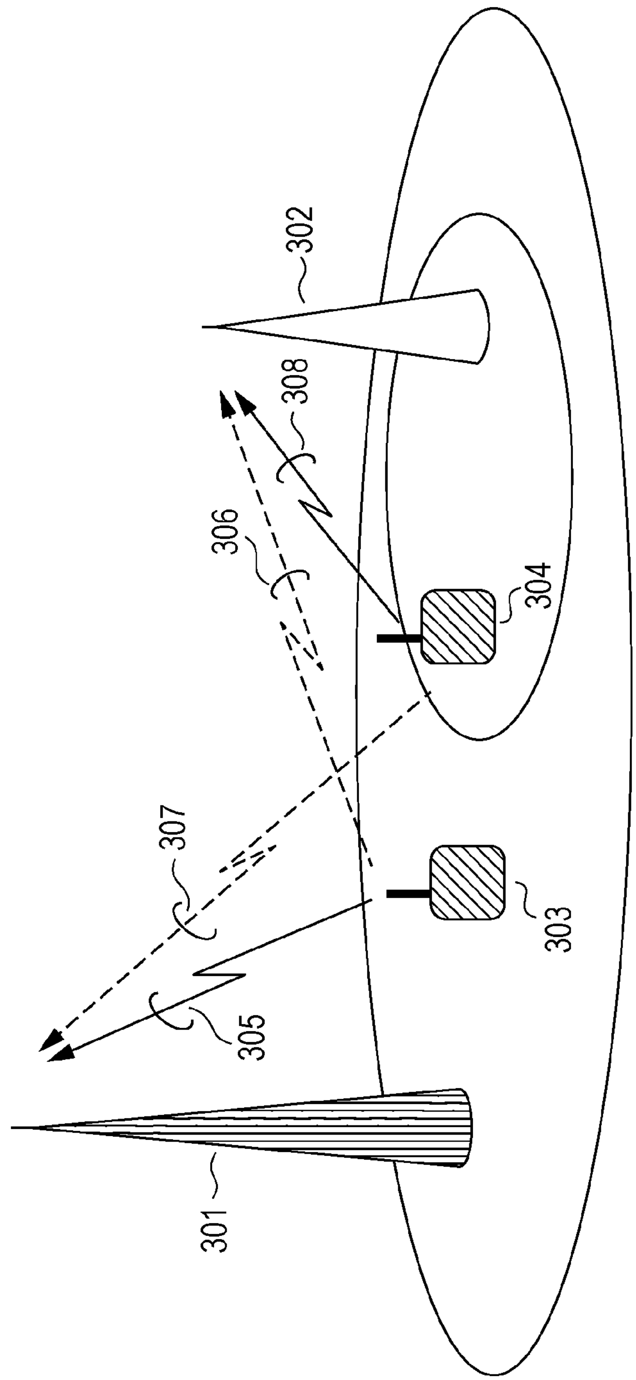


FIG. 4

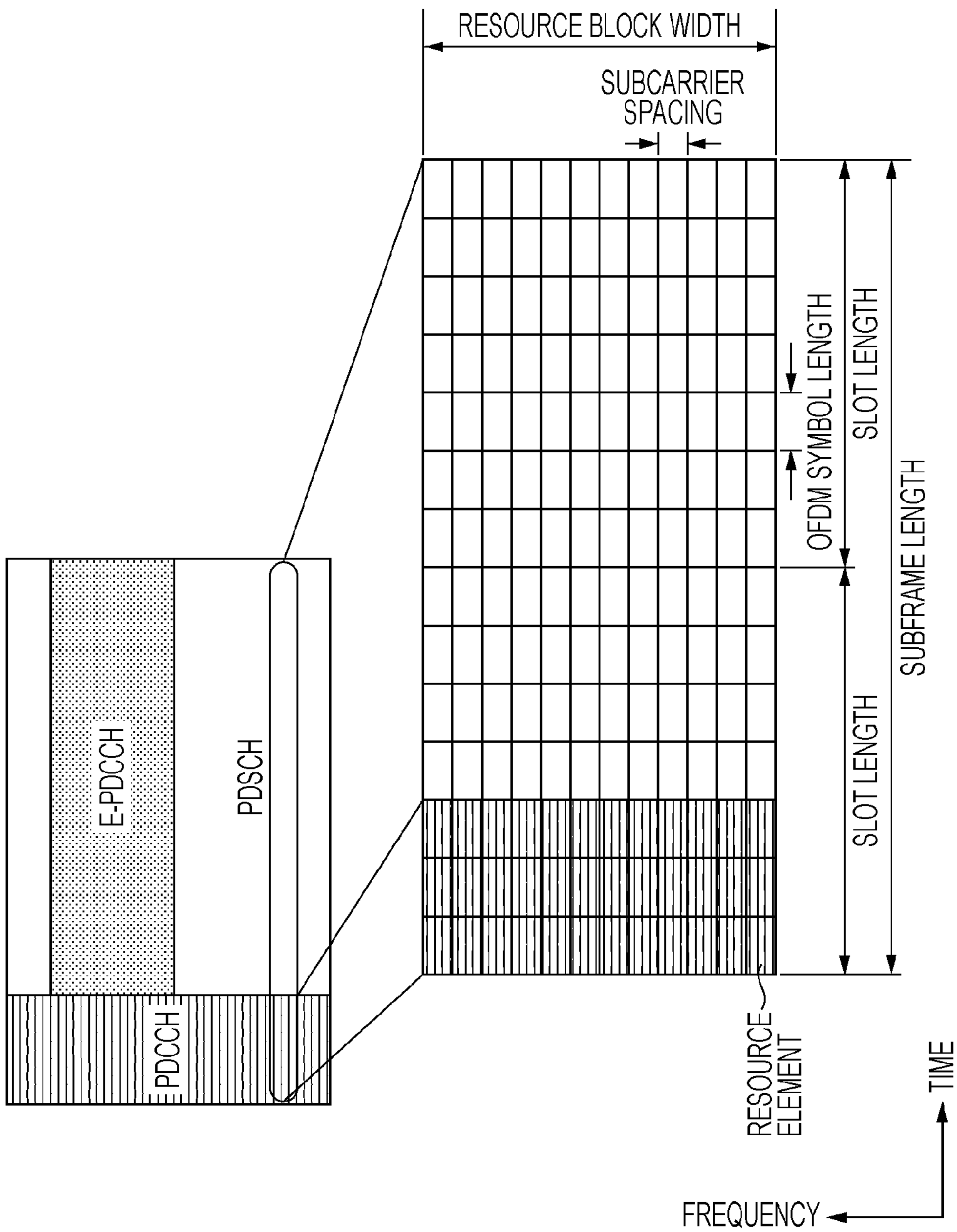
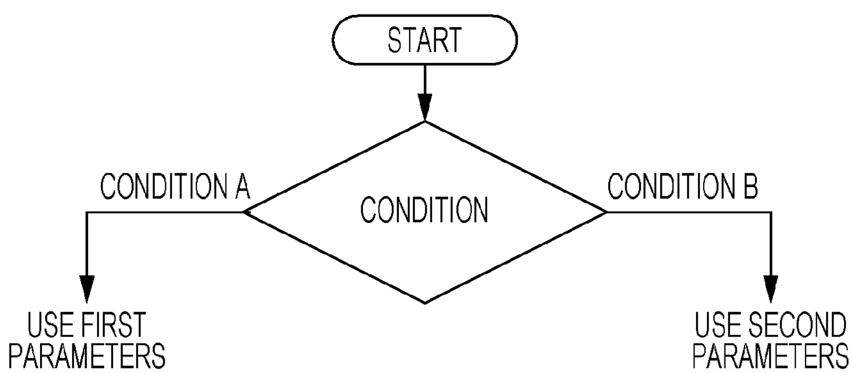

RESOURCE BLOCK WIDTH
SUBCARRIER SPACING
OFDM SYMBOL LENGTH
SLOT LENGTH
SUBFRAME LENGTH
SLOT LENGTH
E-PDCCH
PDSCH
PDCCH
RESOURCE ELEMENT
TIME
FREQUENCY

FIG. 5


START
CONDITION
CONDITION A
CONDITION B
USE FIRST PARAMETERS
USE SECOND PARAMETERS

TERMINAL DEVICE, A BASE STATION DEVICE, A COMMUNICATION METHOD, AND AN INTEGRATED CIRCUIT FOR PROCESSING DEMODULATION REFERENCE SIGNALS

TECHNICAL FIELD

The present invention relates to a terminal device, a base station device, a communication method, an integrated circuit, and a wireless communication system.

Priority is claimed on Japanese Patent Application No. 2012-056895, filed Mar. 14, 2012, the content of which is incorporated herein by reference.

BACKGROUND ART

In wireless communication systems such as systems based on LTE (Long Term Evolution) and LTE-A (LTE-Advanced), which are developed by 3GPP (Third Generation Partnership Project), and WiMAX (Worldwide Interoperability for Microwave Access), which is developed by IEEE (The Institute of Electrical and Electronics engineers), a base station and a terminal each include one or a plurality of transmit/receive antennas, and utilize, for example, MIMO (Multiple Input Multiple Output) technology to achieve high-speed data transmission.

In the wireless communication systems, the support of MU-MIMO (Multiple User MIMO) in which a plurality of terminals perform spatial multiplexing using the same frequency and time resources is being examined. The support of a CoMP (Cooperative Multipoint) transmission scheme in which a plurality of base stations cooperate with one another to perform interference coordination is also being examined. For example, a wireless communication system designed to use heterogeneous network deployment (HetNet) implemented by a wide-coverage macro base station, an RRH (Remote Radio Head) with coverage smaller than the macro base station, and so on is being examined.

In the above-described wireless communication systems, interference occurs if uplink signals (uplink data or uplink control information) transmitted from a plurality of terminals have the same characteristics. Interference also occurs if uplink reference signals transmitted from a plurality of terminals have the same characteristics. To mitigate or eliminate interference between demodulation reference signals (also referred to as DMRSs) transmitted from a plurality of terminals, for example, a method for orthogonalizing the demodulation reference signals has been proposed (NPL 1).

CITATION LIST

Non Patent Literature

NPL 1: DMRS enhancements for UL CoMP; 3GPP TSG RAN WG1 meeting #68 R1-120277, Feb. 6-10, 2012.

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

However, there is no description regarding a specific procedure which allows a base station and a terminal in a wireless communication system to determine parameters related to uplink signals or uplink reference signals. That is, no description is given of how a base station and a terminal determine parameters related to uplink signals or uplink reference signals and perform communication.

The present invention has been made in light of the foregoing problem, and it is an object of the present invention to provide a base station device, a terminal device, a communication method, an integrated circuit, and a communication system that enable a base station and a terminal to determine parameters related to uplink signals or uplink reference signals and to perform efficient communication.

Means for Solving the Problems

(1) To achieve the object described above, the present invention takes the following solutions: A terminal device that transmits a demodulation reference signal associated with a physical uplink shared channel to a base station device includes determining a sequence group number on the basis of a value of a parameter configured by a higher layer, determining the sequence group number on the basis of a physical layer cell identity, and generating a sequence of the demodulation reference signal on the basis of the sequence group number, wherein the sequence group number is determined on the basis of the value of the parameter in a case where a transmission on the physical uplink shared channel is performed in accordance with a downlink control information format to which CRC parity bits scrambled by a C-RNTI are attached, which is transmitted on an enhanced physical downlink control channel (Enhanced-PDCCH), and wherein the sequence group number is determined on the basis of the physical layer cell identity in a case where a transmission on the physical uplink shared channel is performed in accordance with a downlink control information format to which CRC parity bits scrambled by a Temporary C-RNTI are attached, which is transmitted on a physical downlink control channel (PDCCH), in a random access procedure.

(2) In addition, a base station device that receives a demodulation reference signal associated with a physical uplink shared channel from a terminal device, a sequence of the demodulation reference signal being generated on the basis of a sequence group number, includes identifying the sequence group number on the basis of a value of a parameter of a higher layer, and identifying the sequence group number on the basis of a physical layer cell identity, wherein the sequence group number is identified on the basis of the value of the parameter in a case where a downlink control information format to which CRC parity bits scrambled by a C-RNTI are attached, which is transmitted on an enhanced physical downlink control channel (Enhanced-PDCCH), is used for scheduling of a transmission on the physical uplink shared channel, and wherein the sequence group number is identified on the basis of the physical layer cell identity in a case where a downlink control information format to which CRC parity bits scrambled by a Temporary C-RNTI are attached, which is transmitted on a physical downlink control channel (PDCCH), is used for scheduling of a transmission on the physical uplink shared channel in a random access procedure.

(3) In addition, an integrated circuit mountable on a terminal device that transmits a demodulation reference signal associated with a physical uplink shared channel to a base station device causes the terminal device to perform functions including determining a sequence group number on the basis of a value of a parameter configured by a higher layer; determining the sequence group number on the basis of a physical layer cell identity; and generating a sequence of the demodulation reference signal on the basis of the

sequence group number, wherein the integrated circuit causes the terminal device to perform functions including determining the sequence group number on the basis of the value of the parameter in a case where a transmission on the physical uplink shared channel is performed in accordance with a downlink control information format to which CRC parity bits scrambled by a C-RNTI are attached, which is transmitted on an enhanced physical downlink control channel (Enhanced-PDCCH); and determining the sequence group number on the basis of the physical layer cell identity in a case where a transmission on the physical uplink shared channel corresponding to a downlink control information format to which CRC parity bits scrambled by a Temporary C-RNTI are attached, which is transmitted on a physical downlink control channel (PDCCH), is performed in a random access procedure.

(4) In addition, an integrated circuit mountable on a base station device that receives a demodulation reference signal associated with a physical uplink shared channel from a terminal device, a sequence of the demodulation reference signal being generated on the basis of a sequence group number, causes the base station device to perform functions including identifying the sequence group number on the basis of a value of a parameter of a higher layer; and identifying the sequence group number on the basis of a physical layer cell identity, wherein the integrated circuit causes the base station device to perform functions including identifying the sequence group number on the basis of the value of the parameter in a case where a downlink control information format to which CRC parity bits scrambled by a C-RNTI are attached, which is transmitted on an enhanced physical downlink control channel (Enhanced-PDCCH), is used for scheduling of a transmission on the physical uplink shared channel; and identifying the sequence group number on the basis of the physical layer cell identity in a case where a downlink control information format to which CRC parity bits scrambled by a Temporary C-RNTI are attached, which is transmitted on a physical downlink control channel (PDCCH), is used for scheduling of a transmission on the physical uplink shared channel in a random access procedure.

Effects of the Invention

According to the present invention, a base station and a terminal can determine parameters related to uplink signals or uplink reference signals and perform efficient communication.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram illustrating a configuration of a base station according to an embodiment of the present invention.

FIG. **2** is a schematic block diagram illustrating a configuration of a terminal according to the embodiment of the present invention.

FIG. **3** is a schematic diagram illustrating an example of communication according to the embodiment of the present invention.

FIG. **4** is a diagram illustrating an example of a downlink signal.

FIG. **5** is a diagram explaining the embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

An embodiment of the present invention will be described hereinafter. A wireless communication system according to the embodiment of the present invention includes, as base station devices (hereinafter also referred to as base stations, transmitting devices, cells, serving cells, transmit stations, transmission points, transmit antenna groups, transmit antenna port groups, or eNodeBs), a primary base station (also referred to as a macro base station, a first base station, a first communication device, a serving base station, an anchor base station, or a primary cell) and a secondary base station (also referred to as an RRH, a pico base station, a femto base station, a Home eNodeB, a second base station device, a second communication device, a cooperative base station group, a cooperative base station set, a cooperative base station, or a secondary cell). The wireless communication system further includes a mobile station device (hereinafter also referred to as a terminal, a terminal device, a mobile terminal, a receiving device, a reception point, a receiver terminal, a third communication device, a receive antenna group, a receive antenna port group, or user equipment (UE)).

The secondary base station may be one of a plurality of secondary base stations. For example, the primary base station and the secondary base station utilize the heterogeneous network deployment, in which part or all of the coverage of the secondary base station is included in the coverage of the primary base station, to communicate with the terminal.

FIG. **1** is a schematic block diagram illustrating a configuration of a base station according to an embodiment of the present invention. The base station illustrated in FIG. **1** is a primary base station or a secondary base station. The base station includes a data control unit **101**, a transmit data modulation unit **102**, a radio unit **103**, a scheduling unit **104**, a channel estimation unit **105**, a received data demodulation unit **106**, a data extraction unit **107**, a higher layer **108**, and an antenna **109**. The radio unit **103**, the scheduling unit **104**, the channel estimation unit **105**, the received data demodulation unit **106**, the data extraction unit **107**, the higher layer **108**, and the antenna **109** constitute a receiving section. The data control unit **101**, the transmit data modulation unit **102**, the radio unit **103**, the scheduling unit **104**, the higher layer **108**, and the antenna **109** constitute a transmitting section. Here, each of the components constituting the base station is also referred to as a unit.

The data control unit **101** receives transport channels from the scheduling unit **104**. The data control unit **101** maps the transport channels and signals generated in the physical layer to physical channels on the basis of scheduling information input from the scheduling unit **104**. The mapped pieces of data are output to the transmit data modulation unit **102**.

The transmit data modulation unit **102** modulates/codes transmit data. The transmit data modulation unit **102** performs signal processing operations, such as modulation/coding, serial/parallel conversion of input signals, IFFT (Inverse Fast Fourier Transform) processing, and CP (Cyclic Prefix) insertion, on the data input from the data control unit **101** on the basis of the scheduling information supplied from the scheduling unit **104** and so on to generate transmit data, and outputs the transmit data to the radio unit **103**.

The radio unit **103** generates a radio signal by up-converting the transmit data input from the transmit data modulation unit **102** to a radio frequency signal, and transmits the radio signal to a terminal via the antenna **109**. In addition, the radio unit **103** receives a radio signal received from the terminal via the antenna **109**, down-converts the radio signal to a baseband signal, and outputs the received data to the channel estimation unit **105** and the received data demodulation unit **106**.

The scheduling unit **104** performs operations such as mapping between logical channels and transport channels and downlink and uplink scheduling. Since the scheduling unit **104** controls the physical-layer processors in an integrated manner, an interface exists between the scheduling unit **104** and the respective units, namely, the antenna **109**, the radio unit **103**, the channel estimation unit **105**, the received data demodulation unit **106**, the data control unit **101**, the transmit data modulation unit **102**, and the data extraction unit **107**.

In the downlink scheduling, the scheduling unit **104** controls transmission on transport channels and physical channels and generates scheduling information on the basis of uplink control information received from the terminal, scheduling information input from the higher layer **108**, and so on. The scheduling information used for the downlink scheduling is output to the data control unit **101**.

In the uplink scheduling, the scheduling unit **104** generates scheduling information on the basis of an uplink channel state output from the channel estimation unit **105**, the scheduling information input from the higher layer **108**, and so on. The scheduling information used for the uplink scheduling is output to the data control unit **101**.

In addition, the scheduling unit **104** maps downlink logical channels input from the higher layer **108** to transport channels, and outputs the transport channels to the data control unit **101**. The scheduling unit **104** further maps uplink transport channels and control data input from the data extraction unit **107** to uplink logical channels after processing the uplink transport channels and the control data, if necessary, and outputs the uplink logical channels to the higher layer **108**.

The channel estimation unit **105** estimates an uplink channel state from uplink reference signals (e.g., demodulation reference signals) for the demodulation of uplink data, and outputs the uplink channel state to the received data demodulation unit **106**. The channel estimation unit **105** further estimates an uplink channel state from uplink reference signals (e.g., sounding reference signals) for uplink scheduling, and outputs the uplink channel state to the scheduling unit **104**.

The received data demodulation unit **106** demodulates received data. The received data demodulation unit **106** performs a demodulation process on modulated data input from the radio unit **103** by preforming signal processing operations, such as a DFT transform, subcarrier mapping, and an IFFT transform, on the basis of the estimated uplink channel state input from the channel estimation unit **105**, and outputs the received data to the data extraction unit **107**.

The data extraction unit **107** checks the received data input from the received data demodulation unit **106** for correctness, and outputs the check result (e.g., ACK or NACK) to the scheduling unit **104**. In addition, the data extraction unit **107** separates the data input from the received data demodulation unit **106** into transport channels and physical layer control data, and outputs the transport channels and the physical layer control data to the scheduling unit **104**.

The higher layer **108** performs the processing of the radio resource control (RRC) layer and the processing of the MAC (Media Access Control) layer. Since the higher layer **108** controls the lower-layer processors in an integrated manner, an interface exists between the higher layer **108** and the respective units, namely, the scheduling unit **104**, the antenna **109**, the radio unit **103**, the channel estimation unit **105**, the received data demodulation unit **106**, the data control unit **101**, the transmit data modulation unit **102**, and the data extraction unit **107**.

FIG. **2** is a schematic block diagram illustrating a configuration of a terminal according to the embodiment of the present invention. The terminal includes a data control unit **201**, a transmit data modulation unit **202**, a radio unit **203**, a scheduling unit **204**, a channel estimation unit **205**, a received data demodulation unit **206**, a data extraction unit **207**, a higher layer **208**, and an antenna **209**. The data control unit **201**, the transmit data modulation unit **202**, the radio unit **203**, the scheduling unit **204**, the higher layer **208**, and the antenna **209** constitute a transmitting section. The radio unit **203**, the scheduling unit **204**, the channel estimation unit **205**, the received data demodulation unit **206**, the data extraction unit **207**, the higher layer **208**, and the antenna **209** constitute a receiving section. Here, each of the components constituting the terminal is also referred to as a unit.

The data control unit **201** receives transport channels from the scheduling unit **204**. In addition, the data control unit **201** maps the transport channels and signals generated in the physical layer to physical channels on the basis of scheduling information input from the scheduling unit **204**. The mapped pieces of data are output to the transmit data modulation unit **202**.

The transmit data modulation unit **202** modulates/codes transmit data. The transmit data modulation unit **202** performs signal processing operations, such as modulation/coding, serial/parallel conversion of input signals, IFFT processing, and CP insertion, on the data input from the data control unit **201** to generate transmit data, and outputs the transmit data to the radio unit **203**.

The radio unit **203** generates a radio signal by up-converting the transmit data input from the transmit data modulation unit **202** to a radio frequency signal, and transmits the radio signal to a base station via the antenna **209**. In addition, the radio unit **203** receives a radio signal received from the base station via the antenna **209**, down-converts the radio signal to a baseband signal, and outputs the received data to the channel estimation unit **205** and the received data demodulation unit **206**.

The scheduling unit **104** performs operations such as mapping between logical channels and transport channels and downlink and uplink scheduling. Since the scheduling unit **204** controls the physical-layer processors in an integrated manner, an interface exists between the scheduling unit **204** and the respective units, namely, the antenna **209**, the data control unit **201**, the transmit data modulation unit **202**, the channel estimation unit **205**, the received data demodulation unit **206**, the data extraction unit **207**, and the radio unit **203**.

In the downlink scheduling, the scheduling unit **204** controls reception on transport channels and physical channels and generates scheduling information on the basis of downlink control information received from a base station, scheduling information input from the higher layer **208**, and so on. The scheduling information used for the downlink scheduling is output to the data control unit **201**.

In the uplink scheduling, the scheduling unit **204** performs a scheduling process to map the uplink logical channels input from the higher layer **208** to transport channels, and generates scheduling information used for the uplink scheduling, on the basis of downlink control information received from a base station, the scheduling information input from the higher layer **208**, and so on. The scheduling information is output to the data control unit **201**.

In addition, the scheduling unit **204** maps uplink logical channels input from the higher layer **208** to transport channels, and outputs the transport channels to the data control unit **201**. The scheduling unit **204** also outputs channel state information input from the channel estimation unit **205** and a result of checking CRC (Cyclic Redundancy Check) parity bits (also referred to simply as the CRC) which is input from the data extraction unit **207** to the data control unit **201**.

In addition, the scheduling unit **204** determines parameters related to uplink signals, and generates uplink signals using the determined parameters. The scheduling unit **204** further determines parameters related to reference signals, and generates reference signals using the determined parameters.

The channel estimation unit **205** estimates a downlink channel state from downlink reference signals (e.g., demodulation reference signals) for the demodulation of downlink data, and outputs the downlink channel state to the received data demodulation unit **206**. In addition, the received data demodulation unit **206** demodulates received data input from the radio unit **203**, and outputs the received data to the data extraction unit **207**.

The data extraction unit **207** checks the received data input from the received data demodulation unit **206** for correctness, and outputs the check result (e.g., ACK or NACK) to the scheduling unit **204**. In addition, the data extraction unit **207** separates the received data input from the received data demodulation unit **206** into transport channels and physical layer control data, and outputs the transport channels and the physical layer control data to the scheduling unit **204**.

The higher layer **208** performs the processing of the radio resource control layer and the MAC layer. Since the higher layer **208** controls the lower-layer processors in an integrated manner, an interface exists between the higher layer **208** and the respective units, namely, the scheduling unit **204**, the antenna **209**, the data control unit **201**, the transmit data modulation unit **202**, the channel estimation unit **205**, the received data demodulation unit **206**, the data extraction unit **207**, and the radio unit **203**.

FIG. **3** is a schematic diagram illustrating an example of communication according to the embodiment of the present invention. In FIG. **3**, a terminal **303** communicates with a primary base station **301** and/or a secondary base station **302**. In addition, a terminal **304** communicates with the primary base station **301** and/or the secondary base station **302**.

In FIG. **3**, when transmitting an uplink signal to a base station, a terminal transmits the uplink signal with which the demodulation reference signal (DMRS), which is a signal known between the base station and the terminal, is multiplexed. The uplink signal includes uplink data (uplink shared channel (UL-SCH) or an uplink transport block). In addition, the uplink signal includes uplink control information (UCI). Here, the UL-SCH is a transport channel.

For example, the uplink data is mapped to a physical uplink shared channel (PUSCH). The uplink control information is mapped to the PUSCH or a physical uplink control channel (PUCCH). That is, in a wireless communication system, the demodulation reference signal associated with transmission of the PUSCH (transmission on the PUSCH) is supported. In the wireless communication system, furthermore, the demodulation reference signals associated with transmission of the PUCCH (transmission on the PUCCH) is supported.

In the following, the demodulation reference signal associated with transmission of the PUSCH is also represented as a first reference signal. The demodulation reference signal associated with transmission of the PUCCH is also represented as a second reference signal. The first reference signal and the second reference signal are also represented as reference signals.

That is, the first reference signal is used for demodulation of the PUSCH. For example, the first reference signal is transmitted on resource blocks (also referred to as physical resource blocks, physical resources, or resources) to which the corresponding PUSCH is mapped. The second reference signal is used for demodulation of the PUCCH. For example, the second reference signal is transmitted on resource blocks to which the corresponding PUCCH is mapped.

Specifically, the terminal **303** multiplexes the reference signals with the uplink signal that is transmitted to the primary base station **301**, and transmits the uplink signal through an uplink **305**. In addition, the terminal **303** multiplexes the reference signals with the uplink signal that is transmitted to the secondary base station **302**, and transmits the uplink signal through an uplink **306**. The terminal **304** multiplexes the reference signals with the uplink signal that is transmitted to the primary base station **301**, and transmits the uplink signal through an uplink **307**. In addition, the terminal **304** multiplexes the reference signals with the uplink signal that is transmitted to the secondary base station **302**, and transmits the uplink signal through an uplink **308**.

If the uplink signal transmitted from the terminal **303** and the uplink signal transmitted from the terminal **304** have the same characteristics, interference occurs. Interference also occurs if the reference signal transmitted from the terminal **303** and the reference signal transmitted from the terminal **304** have the same characteristics. For example, if interference occurs in reference signals transmitted from a plurality of terminals, the accuracy with which a channel state used for demodulation of uplink signals will be significantly reduced.

To address this, it is desirable to orthogonalize the reference signal transmitted from the terminal **303** and the reference signal transmitted from the terminal **304**. In addition, it is desirable to orthogonalize the uplink signal transmitted from the terminal **303** and the uplink signal transmitted from the terminal **304**. In addition, it is desirable to randomize interference between the reference signal transmitted from the terminal **303** and the reference signal transmitted from the terminal **304**. In addition, it is desirable to randomize interference between the uplink signal transmitted from the terminal **303** and the uplink signal transmitted from the terminal **304**.

In FIG. **3**, different cell identities (also referred to as Cell IDs) (also referred to as Different cell IDs) may be configured for the primary base station **301** and the secondary base station **302**. The same cell identity (also referred to as the Shared cell ID or Same cell ID) may be configured for all or some of the primary base station **301** and the secondary base station **302**. A cell identity is also referred to as a physical layer cell identity (a physical layer cell identifier).

In FIG. **3**, furthermore, an aggregation of a plurality of serving cells (also referred to simply as cells) is supported (referred to as a carrier aggregation or a cell aggregation) in the downlink and the uplink. For example, a transmission bandwidth of up to 110 resource blocks in each of the serving cells can be used. In the carrier aggregation, one of the serving cells is defined as a primary cell (Pcell). In the carrier aggregation, furthermore, the serving cells other than the primary cell are defined as secondary cells (Scells).

In the downlink, a carrier corresponding to the serving cell is defined as a downlink component carrier (DLCC). In the downlink, furthermore, a carrier corresponding to the primary cell is defined as a downlink primary component carrier (DLPCC). In the downlink, furthermore, a carrier corresponding to a secondary cell is defined as a downlink secondary component carrier (DLSCC).

In the uplink, a carrier corresponding to the serving cell is defined as an uplink component carrier (ULCC). In the uplink, furthermore, a carrier corresponding to the primary cell is defined as an uplink primary component carrier (ULPCC). In the uplink, furthermore, a carrier corresponding to a secondary cell is defined as an uplink secondary component carrier (ULSCC).

That is, in the carrier aggregation, a plurality of component carriers are aggregated to support a wide transmission bandwidth. Here, for example, the primary base station **301** may also be regarded as the primary cell, and the secondary base station **302** may also be regarded as a secondary cell (the base station may perform configuration in the terminal) (also referred to as HetNet deployment with a carrier aggregation).

FIG. **4** is a diagram illustrating an example of a downlink signal. In FIG. **4**, physical downlink shared channel (PDSCH) resource regions to which downlink data (downlink shared channel (DL-SCH) or downlink transport blocks) is mapped are illustrated. The DL-SCH is a transport channel.

A physical downlink control channel (PDCCH; Physical Downlink Control Channel) resource region to which downlink control information (DCI; Downlink Control Information) is mapped is also illustrated. In addition, an enhanced physical downlink control channel (Enhanced-PDCCH; E-PDCCH) resource region to which downlink control information is mapped is illustrated.

FIG. **4** also depicts two resource blocks in one subframe. For example, one resource block is composed of 12 subcarriers in the frequency domain and 7 OFDM symbols in the time domain.

In a subframe, each of 7 OFDM symbols in the time domain is also referred to as a slot. In addition, in each slot, a resource defined by one OFDM symbol and one subcarrier is also referred to as a resource element. In a subframe, furthermore, two continuous resource blocks are referred to as a resource block pair.

As illustrated in FIG. **4**, for example, the PDCCH is mapped to the first through third OFDM symbols in a downlink resource region. The PDSCH and the PDCCH are time-division multiplexed.

In addition, the E-PDCCH is mapped to the fourth through twelfth OFDM symbols in the downlink resource region. That is, for example, the E-PDCCH is mapped to the first slot and the second slot. That is, the E-PDCCH is mapped to one resource block pair. In addition, the PDSCH and the E-PDCCH are not subjected to time division multiplexing, space division multiplexing, or code division multiplexing. The PDSCH and the E-PDCCH are subjected to frequency division multiplexing.

It is noted here that the base station can signal information regarding the OFDM symbols used for PDCCH (PDCCH transmission) in a given subframe to the terminal using a PCFICH (Physical Control Format Indicator Channel). For example, as illustrated in FIG. **4**, the base station can signal the use of three OFDM symbols for PDCCH transmission to the terminal.

In addition, the base station can configure the E-PDCCH resource region to the terminal. For example, the base station can configure the E-PDCCH resource region (resource block pair) to the terminal by using a dedicated signal. For example, the base station can configure a resource region that may possibly be used for E-PDCCH (E-PDCCH transmission) (Potential E-PDCCH resource region) to the terminal by using the dedicated signal.

In addition, the PDCCH is transmitted using the same transmit antenna port as that used for the transmission of a cell-specific reference signal. The cell-specific reference signal is also referred to as a common reference signal. That is, the cell-specific reference signal is mapped to resource elements in all the resource blocks.

In addition, the E-PDCCH is transmitted using the same transmit antenna port as that used for the transmission of a terminal-specific (user-equipment-specific; UE-specific) reference signal. That is, the UE-specific reference signal is mapped to resource elements in resource blocks assigned for the transmission of E-PDCCH (or, instead, in resource blocks for the transmission of downlink control information that uses the E-PDCCH). The UE-specific reference signal may be shared by a plurality of terminals.

In the following, the PDCCH is also represented as a first PDCCH. In addition, the E-PDCCH is represented as a second PDCCH.

The PDCCH and the E-PDCCH are used to signal (specify) downlink control information to the terminal. A plurality of formats are defined for downlink control information that is transmitted on the PDCCH and the E-PDCCH. The formats of the downlink control information are also referred to as DCI formats.

For example, DCI format 1 and DCI format 1A, which are used for the scheduling of one PDSCH (transmission of one PDSCH codeword or one downlink transport block) in one cell, are defined as downlink DCI formats. In addition, DCI format 2, which is used for the scheduling of one PDSCH (transmission of up to two PDSCH codewords or up to two downlink transport blocks) in one cell, is defined as a downlink DCI format.

For example, the downlink DCI format includes downlink control information such as information regarding PDSCH resource allocation and information regarding MCS (Modulation and Coding scheme). The downlink DCI format may include information regarding the base sequence index (also referred to as the base sequence identity). The downlink DCI format may include information regarding the base sequence index associated with PUCCH (also referred to as the base sequence identity associated with PUCCH). In the following, the DCI format used for scheduling of the PDSCH is also represented as a downlink assignment.

In addition, for example, DCI format 0, which is used for the scheduling of one PUSCH (transmission of one PUSCH codeword or one uplink transport block) in one cell, is defined as an uplink DCI format. In addition, DCI format 4, which is used for the scheduling of one PUSCH (transmission of up to two PUSCH codewords or up to two uplink transport blocks) in one cell, is defined as an uplink DCI format. That is, the DCI format 4 is used for scheduling of the PUSCH transmission (transmission mode) that uses a plurality of antenna ports.

For example, the uplink DCI format includes downlink control information such as information regarding PUSCH resource allocation and information regarding MCS (Modulation and Coding scheme). The uplink DCI format may include information regarding the base sequence index. In the following, the DCI format used for scheduling of the PUSCH is also represented as an uplink grant.

In FIG. 4, the terminal monitors a set of PDCCH candidates. Here, a PDCCH candidate represents a candidate for which the PDCCH may possibly be allocated and transmitted by the base station. A PDCCH candidate is composed of one or a plurality of control channel elements (CCEs). The term "monitor" means that the terminal attempts to decode each PDCCH in the set of PDCCH candidates in accordance with all the DCI formats to be monitored.

Similarly, the terminal monitors a set of E-PDCCH candidates. Here, an E-PDCCH candidate represents a candidate for which the E-PDCCH may possibly be allocated and transmitted by the base station. An E-PDCCH candidate is composed of one or a plurality of control channel elements (CCEs). The term "monitor" means that the terminal attempts to decode each E-PDCCH in the set of E-PDCCH candidates in accordance with all the DCI formats to be monitored.

The set of PDCCH candidates and/or set of E-PDCCH candidates that the terminal monitors are also referred to as a search space. That is, the search space is a set of resources that may possibly be used by the base station for PDCCH transmission and/or E-PDCCH transmission. In this embodiment, PDCCH candidates and E-PDCCH candidates have been separately described for ease of description. However, E-PDCCH candidates may be described as PDCCH candidates.

That is, a common search space (CSS) and/or a user-equipment-specific search space (USS; UE-Specific Search Space, terminal-specific (terminal-unique) search space) are configured (defined or set) in the PDCCH resource region. In addition, the CSS and/or the USS are configured (defined or set) in the E-PDCCH resource region.

The terminal monitors the PDCCH in the CSS and/or the USS in the PDCCH resource region, and detects a PDCCH addressed to the terminal. In addition, the terminal monitors the E-PDCCH in the CSS and/or the USS in the E-PDCCH resource region, and detects an E-PDCCH addressed to the terminal.

The CSS is used for the transmission of downlink control information to a plurality of terminals. That is, the CSS is defined by a resource common to a plurality of terminals. For example, the CSS is composed of CCEs having numbers that are predetermined between the base station and the terminal. For example, the CSS is composed of CCEs having indices 0 to 15. The CSS may be used for the transmission of downlink control information to a specific terminal. That is, the base station transmits, in the CSS, a DCI format intended for a plurality of terminals and/or a DCI format intended for a specific terminal.

The USS is used for the transmission of downlink control information to a specific terminal. That is, the USS is defined by a resource dedicated to a certain terminal. That is, the USS is defined independently for each terminal. For example, the USS is composed of CCEs having numbers that are determined on the basis of a radio network temporary identifier (RNTI; Radio Network Temporary Identifier) assigned by the base station, a slot number in a radio frame, an aggregation level, or the like. Here, RNTIs include a C-RNTI (Cell RNTI) and a Temporary C-RNTI. That is, the base station transmits, in the USS, a DCI format intended for a specific terminal.

Here, an RNTI assigned to the terminal by the base station is used for the transmission of downlink control information (transmission on the PDCCH or transmission on the E-PDCCH). Specifically, CRC (Cyclic Redundancy Check parity bits (also referred to simply as the CRC), which are generated on the basis of downlink control information (or, instead, DCI format), are attached to the downlink control information, and, after attachment, the CRC parity bits are scrambled by the RNTI.

The terminal attempts to decode the downlink control information with the CRC parity bits scrambled by the RNTI, and detects a PDCCH (or E-PDCCH) in which the CRC is successful as a PDCCH (or E-PDCCH) addressed to the terminal (also referred to as blind decoding). Here, RNTIs include the C-RNTI and the Temporary C-RNTI. That is, the terminal decodes the PDCCH (or E-PDCCH) with the CRC scrambled by the C-RNTI. In addition, the terminal decodes the PDCCH (or E-PDCCH) with the CRC scrambled by the Temporary C-RNTI.

The C-RNTI is a unique identifier used to identify RRC (Radio Resource Control) connection and scheduling. For example, the C-RNTI is used for dynamically scheduled unicast transmission.

The Temporary C-RNTI is an identifier used for a random access procedure. The base station transmits the Temporary C-RNTI by including the Temporary C-RNTI in a random access response. For example, the Temporary C-RNTI is used in the random access procedure to identify a terminal that is currently performing the random access procedure. In addition, the Temporary C-RNTI is used for a retransmission of message 3 in the random access procedure. That is, in order for the terminal to retransmit message 3, the base station transmits downlink control information on the PDCCH (or the E-PDCCH) with the CRC scrambled by the Temporary C-RNTI. That is, the terminal changes the interpretation of the downlink control information on the basis of the type of RNTI by which the CRC has been scrambled.

For example, the terminal executes the random access procedure to take synchronization with the base station in the time domain. In addition, the terminal executes the random access procedure for initial connection establishment. In addition, the terminal executes the random access procedure to make a handover. In addition, the terminal executes the random access procedure for connection re-establishment (connection re-establishment). In addition, the terminal executes a random access procedure to make a request for UL-SCH resources.

When a PDSCH resource is scheduled using downlink control information transmitted on the PDCCH (or E-PDCCH), the terminal receives downlink data on the scheduled PDSCH. When a PUSCH resource is scheduled using downlink control information transmitted on the PDCCH (or E-PDCCH), the terminal transmits uplink data and/or uplink control information on the scheduled PUSCH. As described above, the terminal attempts to decode the downlink control information with the CRC parity bits scrambled by the RNTI, and detects a PDCCH (or E-PDCCH) in which the CRC is successful as a PDCCH (or E-PDCCH) addressed to the terminal. Here, RNTIs include the C-RNTI and the Temporary C-RNTI. Here, the first reference signal is multiplexed with the uplink data and/or the uplink control information transmitted on the PUSCH.

In addition, the terminal transmits the uplink control information on the PUCCH. For example, the terminal transmits information indicating ACK/NACK for downlink data (also referred to as ACK/NACK in HARQ; Hybrid Automatic Repeat Request) on the PUCCH. Here, the terminal transmits the uplink control information using the PUCCH resource corresponding to the number of the first CCE (also referred to as the lowest CCE index used for comprising the PDCCH) which has been used for PDCCH (or E-PDCCH) transmission (used for the transmission of the downlink assignment). Here, the second reference signal is multiplexed in the transmission of the uplink control information transmitted on the PUCCH.

In addition, the base station and the terminal transmit and receive a signal in a higher layer. For example, the base station and the terminal transmit and receive a radio resource control signal (also referred to as RRC signaling; Radio Resource Control signal, RRC message; Radio Resource Control message, or RRC information; Radio Resource Control information) in the RRC layer (Layer 3). Here, dedicated signaling transmitted from the base station to a certain terminal in the RRC layer is also referred to as a dedicated signal (dedicated signaling). That is, configurations (information) specific to (unique to) a certain terminal are signaled by the base station by using the dedicated signal.

In addition, the base station and the terminal transmit and receive a MAC control element in the MAC (Media Access Control) layer (Layer 2). Here, RRC signaling and/or MAC control element is also referred to as higher layer signaling.

An example of a method for generating a reference signal sequence $r^{(\alpha)}_{u,v}$ will be discussed hereinafter. The reference signal sequence is used to generate a sequence of the first reference signal. In addition, the reference signal sequence is used to generate a sequence of the second reference signal. For example, the reference signal sequence is defined in accordance with mathematical expression 1 by a cyclic shift of a base sequence $\bar{r}^{(\alpha)}_{u,v}(n)$.

$$r_{u,v}^{(\alpha)}=e^{j\alpha n}\bar{r}_{u,v}(n),0\leq n\leq M_{SC}^{RS} \quad \text{[Math. 1]}$$

That is, the reference signal sequence is generated by applying the cyclic shift α to the base sequence. In addition, multiple reference signal sequences are defined from a single base sequence through the different values of the cyclic shift α. Here, M_{SC}^{RS} denotes the length of a reference signal sequence, and is represented by, for example, $M_{SC}^{RS}=mN_{SC}^{RB}$. In addition, N_{SC}^{RB} denotes the size of a resource block in the frequency domain, and is represented by, for example, the number of subcarriers.

In addition, the base sequence is divided into groups. That is, the base sequence is represented by a group number (also referred to as a sequence group number) u and a base sequence number v within the corresponding group. For example, the base sequence is divided into 30 groups, and each of the groups includes two base sequences. In addition, a sequence group hopping is applied to the 30 groups. In addition, a sequence hopping is applied to two base sequences in one group.

Here, each of the sequence group number u and the base sequence number v can vary in time. In addition, the definition of a base sequence depends on the sequence length M_{SC}^{RS}. For example, if $M_{SC}^{RS}\geq 3\ N_{SC}^{RB}$, the base sequence is given by mathematical expression 2.

$$\bar{r}_{u,v}(n)=x_q(n \bmod N_{ZC}^{RS}),0\leq n\leq M_{SC}^{MS} \quad \text{[Math. 2]}$$

Here, the q-th root Zadoff-Chu sequence $x_q(m)$ is defined by mathematical expression 3.

$$x_q(m)=e^{-j\frac{\pi q m(m+1)}{N_{ZC}^{RS}}},\ 0\leq m\leq N_{SC}^{RS}-1 \quad \text{[Math. 3]}$$

Here, q is given by mathematical expressions 4.

$$q=\lfloor\bar{q}+1/2\rfloor+v\cdot(-1)^{\lfloor 2\bar{q}\rfloor}$$

$$\bar{q}=N_{ZC}^{RS}\cdot(u+1)/31 \quad \text{[Math. 4]}$$

Here, the Zadoff-Chu sequence length N_{ZC}^{RS} is given by the largest prime number that satisfies $N_{ZC}^{RS}<M_{SC}^{RS}$.

In addition, the sequence group number u in the slot n_s is defined in accordance with mathematical expression 5 using a group hopping pattern $f_{gh}(n_s)$ and a sequence shift pattern f_{ss}.

$$u=(f_{gh}(n_s)+f_{ss})\bmod 30 \quad \text{[Math. 5]}$$

Here, the base station can instruct the terminal to enable or disable the sequence group hopping (also referred to simply as a group hopping).

Here, for example, the group hopping pattern $f_{gh}(n_s)$ is given by mathematical expression 6.

$$f_{gh}(n_s)=\begin{cases}0 & \text{if group hopping is disabled}\\ \left(\sum_{i=0}^{7}c(8n_s+i)\cdot 2^i\right)\bmod 30 & \text{if group hopping is enabled}\end{cases} \quad \text{[Math. 6]}$$

Here, a pseudo random sequence c(i) is defined by mathematical expressions 7. For example, the pseudo random sequence is defined by a Gold sequence of length 31, and is given by mathematical expressions 7.

$$c(n)=(x_1(n+N_C)+x_2(n+N_C))\bmod 2$$

$$x_1(n+31)=(x_1(n+3)+x_1(n))\bmod 2$$

$$x_2(n+31)=(x_2(n+3)+x_2(n+2)+x_2(n+1)+x_2(n))\bmod 2 \quad \text{[Math. 7]}$$

Here, for example, $N_c=1600$. In addition, a first m-sequence x_1 is initialized by $x_1(0)=1$ and $x_1(n)=0$, where n=1, 2, . . . , 30. In addition, a second m-sequence x_2 is initialized by mathematical expression 8.

$$c_{init}=\Sigma_{i=0}^{30}x_2(i)\cdot 2^i \quad \text{[Math. 8]}$$

Here, c_{init} is defined by mathematical expression 9. That is, the pseudo random sequence of the group hopping pattern $f_{gh}(n_s)$ is initialized by mathematical expression 9.

$$c_{init}=\begin{cases}\left\lfloor\frac{N_{ID}^{cell}}{30}\right\rfloor \ldots (1) & \text{if condition } A\\ \left\lfloor\frac{X}{30}\right\rfloor \ldots (2) & \text{if condition } B\end{cases} \quad \text{[Math. 9]}$$

The details of the physical layer cell identity N_{ID}^{cell} and the parameter "X" will be described below.

In addition, the definition of the sequence shift pattern f_{ss} differs between the PUSCH and the PUCCH. For example, for the PUCCH, the sequence shift pattern f_{ss}^{PUCCH} is given by mathematical expression 10. For the PUSCH, the sequence shift pattern f_{ss}^{PUSCH} is given by mathematical expression 11.

$$f_{ss}^{PUCCH}=\begin{cases}N_{ID}^{cell}\bmod 30 \ldots (1) & \text{if condition } A\\ X\bmod 30 \ldots (2) & \text{if condition } B\end{cases} \quad \text{[Math. 10]}$$

$$f_{ss}^{PUSCH}=\begin{cases}(f_{ss}^{PUCCH}+\Delta_{ss})\bmod 30 \ldots (1) & \text{if condition } A\\ (f_{ss}^{PUCCH}+Y)\bmod 30 \ldots (2) & \text{if condition } B\end{cases} \quad \text{[Math. 11]}$$

The details of the physical layer cell identity N_{ID}^{cell} and the parameter "X" will be described below. The details of the parameter Δ_{ss} and the parameter "Y" will be described below.

In addition, the base sequence number v within the base sequence group in the slot n_s is defined by mathematical expression 12. Here, the sequence hopping may be applied only to the reference signals whose lengths are greater than or equal to 6 N_{SC}^{RB}. That is, the base sequence number v is given by v=0 for the reference signals whose lengths are less than 6 N_{SC}^{RB}.

$$v = \begin{cases} c(n_s) & \text{if group hopping is diabled and sequence hopping is enabled} \\ 0 & \text{otherwise} \end{cases} \quad \text{[Math. 12]}$$

Here, the base station can instruct the terminal to enable or disable the sequence hopping.

Here, the pseudo random sequence c(i) is defined by mathematical expressions 7 and mathematical expression 8. In addition, c_{init} is defined by mathematical expression 13. That is, the pseudo random sequence of the base sequence number v is initialized by mathematical expression 13.

$$c_{init} = \begin{cases} \left\lfloor \frac{N_{ID}^{cell}}{30} \right\rfloor \cdot 2^5 + f_{ss}^{PUSCH} \ \ldots (1) & \text{if condition } A \\ \left\lfloor \frac{X}{30} \right\rfloor \cdot 2^5 + f_{ss}^{PUSCH} \ \ldots (2) & \text{if condition } B \end{cases} \quad \text{[Math. 13]}$$

The details of the physical cell identity N_{ID}^{cell} and the parameter "X" will be described below.

An example of a method for generating a sequence of the first reference signal will be discussed hereinafter. That is, a method for generating the demodulation reference signal for the PUSCH will be discussed. For example, a PUSCH demodulation reference signal sequence $\gamma^{(\lambda)}_{PUSCH}(\bullet)$ associated with Layers $\lambda \in \{0, 1, \ldots, \upsilon-1\}$ is defined by mathematical expression 14.

$$r_{PUSCH}^{(\lambda)}(m \cdot M_{SC}^{RS}+n) = w^{(\lambda)}(m) r_{u,v}^{(\alpha_\lambda)}(n) \quad \text{[Math. 14]}$$

Here, υ denotes the number of transmission layers. For example, m is represented as being equal to 0 or 1. In addition, n is represented as being equal to 0, . . . , or $M_{SC}^{RS}-1$. In addition, $M_{SC}^{RS}=M_{SC}^{PUSCH}$, where M_{SC}^{PUSCH} is a bandwidth scheduled for uplink transmission (transmission on the PUSCH) by the base station, and is represented by, for example, the number of subcarriers. Furthermore, $w^{(\lambda)}(m)$ denotes an orthogonal sequence.

In addition, the cyclic shift α_λ in the slot n_s is given by $\alpha_\lambda=2\pi n_{cs,\lambda}$. Here, $n_{cs,\lambda}$ is represented by mathematical expression 15. That is, the cyclic shift applied to the first reference signal associated with PUSCH is defined by mathematical expression 15.

$$n_{cs,\lambda}=(n_{DMRS}^{(1)}+n_{DMRS,\lambda}^{(2)}+n_{PN}(n_s)) \bmod 12 \quad \text{[Math. 15]}$$

Here, $n^{(1)}_{DMRS}$ is signaled by the base station device using the higher layer signaling. In addition, $n^{(2)}_{DMRS,\lambda}$ is indicated by the base station device using the DCI format. In addition, the quantity $n_{PN}(n_s)$ is given by mathematical expression 16.

$$n_{PN}(n_s)=\sum_{i=0}^{7} c(8N_{symb}^{UL}\cdot n_s+i)\cdot 2^i \quad \text{[Math. 16]}$$

Here, the pseudo random sequence c(i) is defined by mathematical expressions 7 and mathematical expression 8. In addition, c_{init} is defined by mathematical expression 17. That is, the cyclic shift applied to the first reference signal associated with the PUSCH is initialized by mathematical expression 17.

$$c_{init} = \begin{cases} \left\lfloor \frac{N_{ID}^{cell}}{30} \right\rfloor \cdot 2^5 + f_{ss}^{PUSCH} \ \ldots (1) & \text{if condition } A \\ Z \ \ldots (2) & \text{if condition } B \end{cases} \quad \text{[Math. 17]}$$

The details of the physical layer cell identity N_{ID}^{cell} and the parameter "Z" will be described below.

An example of a method for generating a sequence of the second reference signal will be discussed hereinafter. That is, a method for generating the demodulation reference signal for the PUCCH will be discussed. For example, a PUCCH demodulation reference signal sequence $\gamma^{(P)}_{PUCCH}(\bullet)$ is defined by mathematical expression 18.

$$r_{PUCCH}^{(p)}(m' N_{RS}^{PUCCH} M_{SC}^{RS} + m M_{SC}^{RS} + n) = \frac{1}{\sqrt{p}} w^{(p)}(m) r_{u,v}^{(\alpha_p)}(n) \quad \text{[Math. 18]}$$

Here, for example, m is represented as being equal to 0, . . . , or $M_{RS}^{PUCCH}-1$. In addition, n is represented as being equal to 0, . . . , or $M_{RS}-1$. In addition, m' is represented as being equal to 0 or 1. Here, p is the number of antenna ports used for PUCCH transmission (transmission on the PUCCH). In addition, the sequence $\gamma^{(\alpha p)}_{u,v}(n)$ is given by mathematical expression 1, where, for example, $M_{SC}^{RS}=12$.

Here, the cyclic shift $\alpha_P(n_s,l)$ is given by mathematical expressions 19. That is, the cyclic shift applied to the second reference signal associated with the PUCCH is defined by mathematical expressions 19.

$$\bar{n}_{oc}^{(p)}(n_s) = \lfloor n'_p(n_s) \cdot \Delta_{shift}^{PUCCH} / N' \rfloor \quad \text{[Math. 19]}$$

$$\alpha_p(n_s, l) = 2\pi \cdot \bar{n}_{sc}^{(p)}(n_s, l) / N_{SC}^{RB}$$

$$\bar{n}_{cs}^{(p)}(n_s, l) = \begin{cases} \left[n_{cs}^{cell}(n_s, l) + \left(\left(n'_p(n_s) \cdot \Delta_{shift}^{PUCCH} + (\bar{n}_{oc}^{(p)}(n_s) \bmod \Delta_{shift}^{PUCCH}) \right) \bmod N' \right) \right] \bmod N_{SC}^{RB} & \text{for normal cyclic prefix} \\ \left[n_{cs}^{cell}(n_s, l) + \left(n'_p(n_s) \cdot \Delta_{shift}^{PUCCH} + (\bar{n}_{oc}^{(p)}(n_s)) \bmod N' \right) \right] \bmod N_{SC}^{RB} & \text{for } \textit{extendedcyclic} \text{ prefix} \end{cases}$$

Here, $n'_P(n_s)$, N', and Δ_{shift}^{PUCCH} are determined on the basis of information and so on signaled by the base station. In addition, the number of reference symbols per slot M_{RS}^{PUCCH} and the sequence w(n) are defined in accordance with the specifications and so on.

In addition, the cyclic shift $n_{cs}^{cell}(n_s,l)$ is defined by mathematical expression 20.

$$n_{cs}^{cell}(n_s,l)=\sum_{i=0}^{7}c(8N_{symb}^{UL}\cdot n_s+8l+i)\cdot 2^i \quad \text{[Math. 20]}$$

Here, N_{symb}^{UL} is the number of symbols in an uplink slot (the number of SC-FDMA symbols). In addition, the pseudo random sequence c(i) is defined by mathematical expressions 7 and mathematical expression 8. In addition, c_{init} is defined by mathematical expression 21 or mathematical expression 22. That is, the cyclic shift applied to the second reference signal associated with the PUCCH is initialized by mathematical expression 21 or mathematical expression 22.

$$c_{init}=\begin{cases} N_{ID}^{cell} \ldots (1) & \text{if condition } A \\ X \ldots (2) & \text{if condition } B \end{cases} \quad \text{[Math. 21]}$$

$$c_{init}=\begin{cases} N_{ID}^{cell} \ldots (1) & \text{if condition } A \\ K \ldots (2) & \text{if condition } B \end{cases} \quad \text{[Math. 22]}$$

The details of the physical layer cell identity N_{ID}^{cell} and the parameter "X" will be described below. The details of the parameter "K" will also be described below. Here, by defining c_{init} using mathematical expression 21, it is possible to use the same parameter "X" for the generation of the first reference signal and the generation of the second reference signal. That is, the parameter "X" that is used for the generation of the first reference signal can also be used for the generation of the second reference signal. The configuration of parameters with efficient use of radio resources is feasible.

The cyclic shift applied to the PUCCH is generated using mathematical expression 20. In addition, c_{init} is defined by mathematical expression 21 or mathematical expression 22. That is, the terminal can transmit on the PUCCH the uplink signal generated using mathematical expression 20 and mathematical expression 21. Alternatively, the terminal can transmit on the PUCCH the uplink signal generated using mathematical expression 20 and mathematical expression 22.

In the mathematical expressions given above, N_{ID}^{cell} denotes a physical layer cell identity (also referred to as a physical layer cell identifier). That is, N_{ID}^{cell} denotes a cell (base station) specific (cell (base station) unique) identity. That is, N_{ID}^{cell} denotes a physical layer identity of a cell. For example, N_{ID}^{cell} may be N_{ID}^{cell} corresponding to the primary cell.

For example, the terminal can detect N_{IC}^{cell} using synchronization signals. In addition, the terminal can acquire N_{ID}^{cell} from information included in the higher layer signaling (e.g., hand over command) transmitted from the base station.

That is, N_{ID}^{cell} is a parameter related to the reference signal sequence (a parameter related to the generation of the reference signal sequence). That is, N_{ID}^{cell} is a parameter related to the first reference signal (a parameter related to the generation of the sequence of the first reference signal). In addition, N_{ID}^{cell} is a parameter related to the second reference signal (a parameter related to the generation of the sequence of the second reference signal). In addition, N_{ID}^{cell} is a parameter related to the PUCCH (a parameter related to the generation of the uplink signal to be transmitted on the PUCCH).

In the mathematical expressions given above, additionally, for example, the parameter Δ_{ss} is denoted by $\Delta_{ss}\in\{0, 1, \ldots, 29\}$. The parameter Δ_{ss} is a cell (base station) specific parameter. For example, the terminal can receive the parameter Δ_{ss} using SIB2 (System Information Block Type2). SIB2 is a configuration common to (information common to) all the terminals (or, instead, a plurality of terminals) within a cell.

That is, the terminal uses information common to all the terminals within the cell to specify the parameter Δ_{ss}. That is, the parameter Δ_{ss} is a parameter related to the first reference signal.

In the mathematical expressions given above, additionally, the parameter "X" (the value of the parameter "X") denotes a virtual cell identity (also referred to as a virtual cell identifier). That is, the parameter "X" denotes a UE-specific identity. That is, the parameter "X" denotes a UE-specific parameter.

That is, the parameter "X" is a parameter related to the reference signal sequence. That is, the parameter "X" is a parameter related to the first reference signal. In addition, the parameter "X" is a parameter related to the second reference signal. In addition, the parameter "X" is a parameter related to the PUCCH.

In the mathematical expressions given above, additionally, for example, the parameter "Y" (the value of the parameter "Y") is denoted by "Y"$\in\{0, 1, \ldots, 29\}$. Here, the parameter "Y" denotes a UE-specific parameter. That is, the parameter "Y" is a parameter related to the first reference signal.

In the mathematical expressions given above, additionally, the parameter "Z" (the value of the parameter "Z") denotes the initial value of the second m-sequence. Here, the parameter "Z" denotes a UE-specific parameter. That is, the parameter "Z" is a parameter related to the first reference signal.

In the mathematical expressions given above, additionally, the parameter "K" (the value of the parameter "K") denotes the initial value of the second m-sequence. Here, the parameter "K" denotes a UE-specific parameter. That is, the parameter "K" is a parameter related to the PUCCH.

Here, the base station can configure the parameter "X" to the terminal using the higher layer signaling. For example, the base station can configure the parameter "X" by using the dedicated signal. The base station may configure a plurality of parameters "X" by using the dedicated signal, and indicate one parameter "X" among the configured plurality of parameters "X" using downlink control information transmitted on the PDCCH (e.g., using the information regarding the base sequence index or using the base sequence index associated with the PUCCH).

That is, downlink control information for indicating the parameter "X" is included in the uplink grant. Downlink control information for indicating the parameter "X" may be included in the downlink assignment.

For example, the base station can configure (X_0) and (X_1) as the plurality of parameters "X", and indicate (X_0) or (X_1) using downlink control information (e.g., 1-bit information) transmitted on the PDCCH.

In addition, the base station can configure the parameter "Y" to the terminal using the higher layer signaling. For example, the base station can configure the parameter "Y" by using the dedicated signal. The base station may configure a plurality of parameters "Y" by using the dedicated signal, and indicate one parameter "Y" among the configured plurality of parameters "Y" using downlink control information transmitted on the PDCCH (e.g., using the information regarding the base sequence index). That is, downlink control information for indicating the parameter "Y" is included in the uplink grant.

For example, the base station can configure (Y_0) and (Y_1) as a plurality of parameters "Y", and indicate (Y_0) or (Y_1) using downlink control information (e.g., 1-bit information) transmitted on the PDCCH.

In addition, the base station can configure the parameter "Z" to the terminal using the higher layer signaling. For example, the base station can configure the parameter "Z" by using the dedicated signal. The base station may configure a plurality of parameters "Z" by using the dedicated signal, and indicate one parameter "Z" among the configured plurality of parameters "Z" using downlink control information transmitted on the PDCCH (e.g., using the information regarding the base sequence index). That is, downlink control information for indicating the parameter "Z" is included in the uplink grant.

For example, the base station can configure (Z_0) and (Z_1) as a plurality of parameters "Z", and indicate (Z_0) or (Z_1) using downlink control information (e.g., 1-bit information) transmitted on the PDCCH.

In addition, the base station can configure the parameter "K" to the terminal using the higher layer signaling. For example, the base station can configure the parameter "K" by using the dedicated signal. The base station may configure a plurality of parameters "K" by using the dedicated signal, and indicate one parameter "K" among the configured plurality of parameters "K" using downlink control information transmitted on the PDCCH (e.g., using the information regarding the base sequence index associated with the PUCCH). That is, downlink control information for indicating the parameter "K" is included in the downlink assignment.

For example, the base station can configure (K_0) and (K_1) as the plurality of parameters "K", and indicate (K_0) or (K_1) using downlink control information (e.g., 1-bit information) transmitted on the PDCCH.

Furthermore, the base station may configure a plurality of sets of parameters "X" and/or parameters "Y" and/or parameters "Z" and/or parameters "K" by using the dedicated signal, and indicate one set among the configured plurality of sets using downlink control information transmitted on the PDCCH (e.g., using the information regarding the base sequence index or using the information regarding the base sequence index associated with the PUCCH).

That is, downlink control information for indicating one set among the plurality of sets is included in the uplink grant. Downlink control information for indicating one set from among the plurality of sets may be included in the downlink assignment.

Here, the parameter "X", the parameter "Y", the parameter "Z", and the parameter "K" may be independently configured. The parameter "X" and/or the parameter "Y" and/or the parameter "Z" and/or the parameter "K" may be configured in association with each other. For example, by notifying the terminal of only the parameter "X", the base station can indicate the parameter "Y" and/or the parameter "Z" and/or the parameter "K" associated with the parameter "X".

For example, the association of the parameter "X" with the parameter "Y" and/or the parameter "Z" and/or the parameter "K" can be defined in advance in accordance with the specifications and so on, and can be set as information known between the base station and the terminal.

In the following, a description is given of a set of parameters which include the parameter "X", the parameter "Y", the parameter "Z", and the parameter "K", for ease of description. A similar embodiment may apply to a set of parameters which include the parameter "X" and/or the parameter "Y" and/or the parameter "Z" and/or the parameter "K".

For example, the base station can configure (X_0, Y_0, Z_0, K_0) and (X_1, Y_1, Z_1, K_1) as a plurality of sets of parameters, and indicate (X_0, Y_0, Z_0, K_0) or (X_1, Y_1, Z_1, K_1) using downlink control information (e.g., 1-bit information) transmitted on the PDCCH.

In a case where the parameters (X_0, Y_0, Z_0, K_0) are indicated using downlink control information transmitted on the PDCCH, the terminal generates the first reference signal using the parameters (X_0, Y_0, Z_0, K_0). In a case where the parameters (X_1, Y_1, Z_1, K_1) are indicated using downlink control information transmitted on the PDCCH, the terminal generates the first reference signal using the parameters (X_1, Y_1, Z_1, K_1).

In addition, in a case where the parameters (X_0, Y_0, Z_0, K_0) are indicated using downlink control information transmitted on the PDCCH, the terminal generates the second reference signal using the parameters (X_0, Y_0, Z_0, K_0). In a case where the parameters (X_1, Y_1, Z_1, K_1) are indicated using downlink control information transmitted on the PDCCH, the terminal generates the second reference signal using the parameters (X_1, Y_1, Z_1, K_1).

In the following, the physical layer cell identity N_{ID}^{cell} and/or the parameter Δ_{ss} are also represented as first parameters. In addition, the parameter "X" and/or the parameter "Y" and/or the parameter "Z" and/or the parameter "K" are also represented as second parameters.

As illustrated in FIG. **5**, the terminal identifies a condition, and switches parameters related to the first reference signal (or, instead, related to the generation of the sequence of the first reference signal) on the basis of the condition. Specifically, if the condition is A, the terminal generates the first reference signal using the first parameters in the mathematical expressions given above.

In addition, the terminal identifies the condition, and switches parameters related to the second reference signal (or, instead, related to the generation of the sequence of the second reference signal) on the basis of the condition. Specifically, if the condition is A, the terminal generates the second reference signal using the first parameters in the mathematical expressions given above.

In addition, the terminal identifies the condition, and switches parameters related to the PUCCH (or, instead, related to the generation of the uplink signal to be transmitted on the PUCCH) on the basis of the condition. Specifically, if the condition is A, the terminal generates the uplink signal to be transmitted on the PUCCH using the first parameters in the mathematical expressions given above.

Specifically, if the condition is A, the terminal maps the first reference signal (or, instead, part of the sequence of the first reference signal) generated using the first parameters to resource elements in the resource blocks allocated for PUSCH transmission (transmission on the PUSCH).

In addition, if the condition is A, the terminal maps the second reference signal (or, instead, part of the sequence of the second reference signal) generated using the first parameters to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, if the condition is A, the terminal maps the uplink signal generated using the first parameters to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, the base station identifies the condition, and switches parameters related to the first reference signal (or, instead, related to the generation of the sequence of the first reference signal) on the basis of the condition. Specifically, if the condition is A, the base station assumes that first reference signal is generated using the first parameters in the mathematical expressions given above.

In addition, the base station identifies the condition, and switches parameters related to the second reference signal (or, instead, related to the generation of the sequence of the second reference signal) on the basis of the condition. Specifically, if the condition is A, the base station assumes that second reference signal is generated using the first parameters in the mathematical expressions given above.

In addition, the base station identifies the condition, and switches parameters related to the PUCCH (or, instead, related to the generation of the uplink signal to be transmitted on the PUCCH) on the basis of the condition. Specifically, if the condition is A, the base station assumes that the uplink signal to be transmitted on the PUCCH is generated using the first parameters in the mathematical expressions given above.

Specifically, if the condition is A, the base station assumes that the first reference signal (or, instead, part of the sequence of the first reference signal) generated using the first parameters is mapped to resource elements in the resource blocks allocated for PUSCH transmission (transmission on the PUSCH).

In addition, if the condition is A, the base station assumes that the second reference signal (or, instead, part of the sequence of the second reference signal) generated using the first parameters is mapped to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, if the condition is A, the base station assumes that the uplink signal generated using the first parameters is mapped to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

If the condition is B, the terminal generates the first reference signal using the second parameters in the mathematical expressions given above. In addition, if the condition is B, the terminal generates the second reference signal using the second parameters in the mathematical expressions given above. In addition, if the condition is B, the terminal generates the uplink signal to be transmitted on the PUCCH using the second parameters in the mathematical expressions given above.

Specifically, if the condition is B, the terminal maps the first reference signal (or, instead, part of the sequence of the first reference signal) generated using the second parameters to resource elements in the resource blocks allocated for PUSCH transmission (transmission on the PUSCH).

In addition, if the condition is B, the terminal maps the second reference signal (or, instead, part of the sequence of the second reference signal) generated using the second parameters to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, if the condition is B, the terminal maps the uplink signal generated using the second parameters to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, if the condition is B, the base station assumes that the first reference signal is generated using the second parameters in the mathematical expressions given above. In addition, if the condition is B, the terminal assumes that the second reference signal is generated using the second parameters in the mathematical expressions given above. In addition, if the condition is B, the terminal assumes that the uplink signal to be transmitted on the PUCCH is generated using the second parameters in the mathematical expressions given above.

Specifically, if the condition is B, the base station assumes that the first reference signal (or, instead, part of the sequence of the first reference signal) generated using the second parameters is mapped to resource elements in the resource blocks allocated for PUSCH transmission (transmission on the PUSCH).

In addition, if the condition is B, the base station assumes that the second reference signal (or, instead, part of the sequence of the second reference signal) generated using the second parameters is mapped to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

In addition, if the condition is B, the base station assumes that the uplink signal generated using the second parameters is mapped to resource elements in the resource blocks allocated for PUCCH transmission (transmission on the PUCCH).

The condition A includes that the E-PDCCH is detected (decoded) in the CSS, or the PDCCH is detected (decoded) in any search space (the CSS or the USS). That is, the condition A includes that the E-PDCCH is detected (decoded) in the CSS. In addition, the condition A includes that the PDCCH is detected (decoded) in the CSS or the USS.

Specifically, in a case where the E-PDCCH is detected in the CSS, the terminal transmits the first reference signal generated using the first parameters. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH is detected in the CSS, the terminal transmits the second reference signal generated using the first parameters. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH is detected in the CSS, the terminal transmits on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits on the PUCCH the uplink signal generated using the first parameters.

In addition, in a case where the E-PDCCH is allocated in the CSS, the base station receives the first reference signal generated using the first parameters. In addition, in a case where the PDCCH is allocated in the CSS or the USS, the base station receives the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH is allocated in the CSS, the base station receives the second reference signal generated using the first parameters. In addition, in a case where the PDCCH is allocated in the CSS or the USS, the base station receives the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH is allocated in the CSS, the base station receives on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH is allocated in the CSS or the USS, the base station receives on the PUCCH the uplink signal generated using the first parameters.

Specifically, in a case where the E-PDCCH is detected in the CSS, the terminal transmits the first reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits the first reference signal generated using N_{ID}^{cell}. In addition, in a case where the E-PDCCH is detected in the CSS, the terminal transmits the first reference signal generated using the parameter Δ_{ss}. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits the first reference signal generated using the parameter Δ_{ss}.

In addition, in a case where the E-PDCCH is detected in the CSS, the terminal transmits the second reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits the second reference signal generated using N_{ID}^{cell}.

In addition, in a case where the E-PDCCH is detected in the CSS, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH is detected in the CSS or the USS, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}.

In addition, the condition B includes that the E-PDCCH is detected (decoded) in the USS. As described above, the detection (decoding) of the PDCCH in the USS is included in the condition A. Specifically, in a case where the E-PDCCH is detected in the USS, the terminal transmits the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the E-PDCCH is allocated in the USS, the base station receives the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH is allocated in the USS, the base station receives the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH is allocated in the USS, the base station receives on the PUCCH the uplink signal generated using the second parameters.

Specifically, in a case where the E-PDCCH is detected in the USS, the terminal transmits the first reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits the first reference signal generated using the parameter "Y". In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits the first reference signal generated using the parameter "Z".

In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits the second reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the parameter "X". In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits the second reference signal generated using the parameter "K". In addition, in a case where the E-PDCCH is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the parameter "K".

Here, downlink control information for indicating the parameters (e.g., the information regarding the base sequence index or the information regarding the base sequence index associated with the PUCCH) is transmitted on the E-PDCCH in the USS.

That is, the terminal transmits, to the base station, the first reference signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information and on the basis of the search space. In addition, the terminal generates the first reference signal using a different method on the basis of whether the PDCCH is detected in the USS or the E-PDCCH is detected in the USS.

In addition, the terminal transmits, to the base station, the second reference signal generated using a different method on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information and on the basis of the search space. In addition, the terminal generates the second reference signal using a different method on the basis of whether the PDCCH is detected in the USS or the E-PDCCH is detected in the USS.

In addition, the terminal transmits on the PUCCH the uplink signal generated using a different method on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information and on the basis of the search space. In addition, the terminal transmits on the PUCCH the uplink signal generated using a different method on the basis of whether the PDCCH is detected in the USS or the E-PDCCH is detected in the USS.

Specifically, in a case where the PDCCH is detected in the USS, the terminal transmits the reference signals associated with the transmission of the physical uplink channel, which are generated using the first parameters. In a case where the E-PDCCH is detected in the USS, the terminal transmits the reference signals associated with the transmission of the physical uplink control channel, which are generated using the second parameters.

In addition, in a case where the PDCCH is allocated in the USS, the base station receives the reference signals associated with the transmission of physical uplink channels, which are generated using the first parameters. In a case where the E-PDCCH is allocated in the USS, the base station receives the reference signals associated with the transmission of physical uplink channels, which are generated using the second parameters.

Here, the physical uplink channels include the PUSCH. In addition, the physical uplink channels include the PUCCH.

In addition, in a case where the PDCCH is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the first parameters. In a case where the E-PDCCH is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the PDCCH is allocated in the USS, the base station receives on the PUCCH the uplink signal generated using the first parameters. In a case where the E-PDCCH is allocated in the USS, the base station receives on the PUCCH the uplink signal generated using the second parameters.

In addition, the condition A includes that the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected (decoded), or the PDCCH with the CRC scrambled by any RNTI (the Temporary C-RNTI or the C-RNTI) is detected (decoded). That is, the condition A includes that the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected (decoded). In addition, the condition A includes that the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected (decoded).

Specifically, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits the first reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits the second reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated, the base station receives the first reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is allocated, the base station receives the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated, the base station receives the second reference signal generated using the first parameters. In addition in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is allocated, the base station receives the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated, the base station receives on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is allocated, the base station receives on the PUCCH the uplink signal generated using the first parameters.

Specifically, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits the first reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH with the CRC scrambled with the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits the first reference signal generated using N_{ID}^{cell}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits the first reference signal generated using the parameter Δ_{ss}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits the first reference signal generated using the parameter Δ_{ss}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits the second reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits the second reference signal generated using N_{ID}^{cell}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}.

In addition, the condition B includes that the E-PDCCH with the CRC scrambled by the C-RNTI is detected (decoded). As described above, the detection (decoding) of the PDCCH with the CRC scrambled by the C-RNTI is included in the condition A. Specifically, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives on the PUCCH the uplink signal generated using the second parameters.

Specifically, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the first reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the first reference signal generated using the parameter "Y". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the first reference signal generated using the parameter "Z".

In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the second reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the second reference signal generated using the parameter "K". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the parameter "K".

Here, the downlink control information for indicating the parameters (e.g., the information regarding the base sequence index or the information regarding the base sequence index associated with the PUCCH) is transmitted on the E-PDCCH with the CRC scrambled by the C-RNTI.

That is, the terminal transmits, to the base station, the first reference signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information and on the basis of the RNTI by which the CRC is scrambled. In addition, the terminal generates the first reference signal using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI or the E-PDCCH with the CRC scrambled by the C-RNTI is used.

In addition, the terminal transmits, to the base station, the second reference signal generated using a different method on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information and on the basis of the RNTI by which the CRC is scrambled. In addition, the terminal generates the second reference signal using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI or the E-PDCCH with the CRC scrambled by the C-RNTI is used.

In addition, the terminal transmits on the PUCCH the uplink signal generated using a different method on the basis of the PDCCH (PDCCH or E-PDCCH) used for the transmission of downlink control information and on the basis of the RNTI by which the CRC is scrambled. In addition, the terminal transmits on the PUCCH the uplink signal generated using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI or the E-PDCCH with the CRC scrambled by the C-RNTI is used.

Specifically, in a case where the PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the reference signals associated with the transmission of physical uplink channels, which are generated using the first parameters. In a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits the reference signals associated with the transmission of physical uplink channels, which are generated using the second parameters.

In addition, in a case where the PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives the reference signals associated with the transmission of physical uplink channels, which are generated using the first parameters. In a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives the reference signals associated with the transmission of physical uplink channels, which are generated using the second parameters.

In addition, in a case where the PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the first parameters. In a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives on the PUCCH the uplink signal generated using the first parameters. In a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated, the base station receives on the PUCCH the uplink signal generated using the second parameters.

In addition, the condition A includes that the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected (decoded) in the CSS, or the PDCCH with the CRC scrambled by any RNTI (the Temporary C-RNTI or the C-RNTI) is detected (decoded) in any search space (the CSS or the USS).

Specifically, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits the first reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected in the CSS or the USS, the terminal transmits the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits the second reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected in the CSS or the USS, the terminal transmits the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled with the Temporary C-RNTI is detected in the CSS, the terminal transmits on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled with the Temporary C-RNTI or the C-RNTI is detected in the CSS or the USS, the terminal transmits on the PUCCH the uplink signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated in the CSS, the base station receives the first reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is allocated in the CSS or the USS, the base station receives the first reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated in the CSS, the base station receives the second reference signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled with the Temporary C-RNTI or the C-RNTI is allocated in the CSS or the USS, the base station receives the second reference signal generated using the first parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is allocated in the CSS, the base station receives on the PUCCH the uplink signal generated using the first parameters. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is allocated in the CSS or the USS, the base station receives on the PUCCH the uplink signal generated using the first parameters.

Specifically, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits the first reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected in the CSS or USS, the terminal transmits the first reference signal generated using N_{ID}^{cell}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits the first reference signal generated using the parameter Δ_{ss}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or C-RNTI is detected in the CSS or the USS, the terminal transmits the first reference signal generated using the parameter Δ_{ss}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits the second reference signal generated using N_{ID}^{cell}. In addition, in a case where the PDCCH with the CRC scrambled by the Temporary C-RNTI or the C-RNTI is detected in the CSS or the USS, the terminal transmits the second reference signal generated using N_{ID}^{cell}.

In addition, in a case where the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}. In addition, in a case where the

PDCCH with the CRC scrambled by the Temporary C-RNTI or C-RNTI is detected in the CSS or the USS, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}.

In addition, the condition B includes that the E-PDCCH with the CRC scrambled by the C-RNTI is detected (decoded) in the USS. Specifically, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated in the USS, the base station receives the first reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated in the USS, the base station receives the second reference signal generated using the second parameters. In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is allocated in the USS, the base station receives on the PUCCH the uplink signal generated using the second parameters.

Specifically, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the first reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the first reference signal generated using the parameter "Y". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the first reference signal generated using the parameter "Z".

In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the second reference signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the parameter "X". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits the second reference signal generated using the parameter "K". In addition, in a case where the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS, the terminal transmits on the PUCCH the uplink signal generated using the parameter "K".

Here, the downlink control information for indicating the parameters (e.g., the information regarding the base sequence index or the information regarding the base sequence index associated with the PUCCH) is transmitted on the E-PDCCH, in the USS, with the CRC scrambled by the C-RNTI.

That is, the terminal transmits, to the base station, the first reference signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, and on the basis of the search space. In addition, the terminal generates the first reference signal using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS or the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS.

In addition, the terminal transmits, to the base station, the second reference signal generated using a different method on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, and on the basis of the search space. In addition, the terminal generates the second reference signal using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS or the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS.

In addition, the terminal transmits on the PUCCH the uplink signal generated using a different method on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, and on the basis of the search space. In addition, the terminal generates the uplink signal using a different method on the basis of whether the E-PDCCH with the CRC scrambled by the Temporary C-RNTI is detected in the CSS or the E-PDCCH with the CRC scrambled by the C-RNTI is detected in the USS.

In addition, the condition A includes that a predetermined DCI format (hereinafter referred to as a first DCI format) is received (detected, decoded). The first DCI format may be information that is defined in advance in accordance with the specifications and so on and that is known between the base station and the terminal. For example, the first DCI format includes a DCI format that is transmitted only in the CSS on the E-PDCCH (in the E-PDCCH resource region). In addition, the first DCI format includes a DCI format that is transmitted only in the CSS and/or the USS on the PDCCH (in the PDCCH resource region).

That is, in a case where the first DCI format is received, the terminal transmits the first reference signal generated using the first parameters. In addition, in a case where the first DCI format is received, the terminal transmits the second reference signal generated using the first parameters. In addition, in a case where the first DCI format is received, the terminal transmits on the PUCCH the uplink signal generated using the first parameters.

In addition, in a case where the first DCI format is transmitted, the base station receives the first reference signal generated using the first parameters. In addition, in a case where the first DCI format is transmitted, the base station receives the second reference signal generated using the first parameters. In addition, in a case where the first DCI format is transmitted, the base station receives on the PUCCH the uplink signal generated using the first parameters.

Specifically, in a case where the first DCI format is received, the terminal transmits the first reference signal generated using N_{ID}^{cell}. In addition, in a case where the first DCI format is received, the terminal transmits the second reference signal generated using N_{ID}^{cell}. In addition, in a case where the first DCI format is received, the terminal transmits on the PUCCH the uplink signal generated using N_{ID}^{cell}. In addition, in a case where the first DCI format is received, the terminal transmits the first reference signal generated using the parameter Δ_{ss}.

In addition, the condition B includes that a DCI format other than the predetermined DCI format (hereinafter referred to as a second DCI format) is received (detected).

For example, the second DCI format includes a DCI format that is transmitted only in the USS on the E-PDCCH (in the E-PDCCH resource region).

That is, in a case where the second DCI format is received, the terminal transmits the first reference signal generated using the second parameters. In addition, in a case where the second DCI format is received, the terminal transmits the second reference signal generated using the second parameters. In addition, in a case where the second DCI format is received, the terminal transmits on the PUCCH the uplink signal generated using the second parameters.

In addition, in a case where the second DCI format is transmitted, the base station receives the first reference signal generated using the second parameters. In addition, in a case where the second DCI format is transmitted, the base station receives the second reference signal generated using the second parameters. In addition, in a case where the second DCI format is transmitted, the base station receives on the PUCCH the uplink signal generated using the second parameters.

Specifically, in a case where the second DCI format is received, the terminal transmits the first reference signal generated using the parameter "X". In addition, in a case where the second DCI format is received, the terminal transmits the first reference signal generated using the parameter "Y". In addition, in a case where the second DCI format is received, the terminal transmits the first reference signal generated using the parameter "Z".

In addition, in a case where the second DCI format is received, the terminal transmits the second reference signal generated using the parameter "X". In addition, in a case where the second DCI format is received, the terminal transmits the second reference signal generated using the parameter "K". In addition, in a case where the second DCI format is received, the terminal transmits on the PUCCH the uplink signal generated using the parameter "K".

Here, the downlink control information for indicating the parameters (e.g., the base sequence index or the base sequence index associated with the PUCCH) is included in the second DCI format and is transmitted.

That is, the terminal transmits, to the base station, the first reference signal generated using a different method (using a different parameter) on the basis of the received DCI format. In addition, the terminal transmits, to the base station, the second reference signal generated using a different method on the basis of the received DCI format. In addition, the terminal performs transmission on the PUCCH generated using a different method on the basis of the received DCI format.

That is, the terminal transmits, to the base station, the first reference signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, on the basis of the search space, and on the basis of the DCI format.

In addition, the terminal transmits, to the base station, the second reference signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, on the basis of the search space, and on the basis of the DCI format.

That is, the terminal transmits on the PUCCH the uplink signal generated using a different method (using a different parameter) on the basis of the PDCCH (the PDCCH or the E-PDCCH) used for the transmission of downlink control information, on the basis of the RNTI by which the CRC is scrambled, on the basis of the search space, and on the basis of the DCI format.

Using the method described above, it is possible to transmit and receive the reference signals while, for example, more flexibly switching between the sequences. In addition, using the method described above, it is possible to transmit and receive the reference signals while more dynamically switching between the sequences.

For example, it is possible to transmit and receive the reference signals using the condition A within a period during which the base station and the terminal perform configuration for the RRC layer. That is, it is possible to transmit and receive the reference signals using the condition A within a period during which ambiguous (unclear) configurations are provided (a period during which configurations are inconsistent between the base station and the terminal), which occurs in the configuration in the RRC layer.

As described above, in the case of the condition A, the terminal generates the reference signals using cell-specific parameters. That is, continuous communication is possible even within a period during which the base station and the terminal perform configuration in the RRC layer, and it is possible to achieve communication with efficient use of radio resources.

In addition, using the method described above, it is possible to transmit and receive the uplink signal while, for example, more flexibly switching between the sequences. In addition, using the method described above, it is possible to transmit and receive the uplink signal while more dynamically switching between the sequences.

For example, it is possible to transmit and receive the uplink signal using the condition A within a period during which the base station and the terminal perform configuration in the RRC layer. That is, it is possible to transmit and receive the uplink signal using the condition A within a period during which ambiguous (unclear) configurations are provided (a period during which configurations are inconsistent between the base station and the terminal), which occurs in the configuration in the RRC layer.

As described above, in the case of the condition A, the terminal generates the uplink signal using the cell-specific parameters. That is, continuous communication is possible even within a period during which the base station and the terminal perform configuration in the RRC layer, and it is possible to achieve communication with efficient use of radio resources.

A program executable on a primary base station, a secondary base station, and a terminal according to the present invention is a program (a program for causing a computer to function) for controlling a CPU and so on to implement the functions in the foregoing embodiments according to the present invention. Information handled by these devices is temporarily accumulated in a RAM when it is processed, and is then stored in various ROMs or HDDs. The program is read, modified, and written by the CPU, as necessary. A recording medium storing the program may be a semiconductor medium (e.g., a ROM, a non-volatile memory card, etc.), an optical recording medium (e.g., a DVD, an MO, an MD, a CD, a BD, etc.), or a magnetic recording medium (e.g., a magnetic tape, a flexible disk, etc.). Furthermore, the loaded program is executed to implement the functions in the embodiments described above. In addition, in some cases, the functions in the present invention may be implemented by processing, in accordance with the instructions of the program, the program in cooperation with an operating system, any other application program, or the like.

In order to distribute the program in a market, the program may be stored in portable recording media for distribution, or may be transferred to a server computer connected via a network such as the Internet. In this case, a storage device in the server computer is also embraced by the present invention. In addition, part or all of a primary base station, a secondary base station, and a terminal in the embodiments described above may be implemented as an LSI, which is typically an integrated circuit. The respective functional blocks of the primary base station, the secondary base station, and the terminal may be built into individual chips, or some or all of them may be integrated and built into a chip. The implementation of the method for forming an integrated circuit is not limited to LSI, and the method may be implemented by dedicated circuitry, a general-purpose processor, or the like. Additionally, in the case of the advent of integrated circuit technology replacing LSI due to the advancement of semiconductor technology, it is also possible to use an integrated circuit based on this technology.

While embodiments of this invention have been described in detail with reference to the drawings, specific configurations are not limited to those of the embodiments, and any design changes and the like can be made without departing from the scope of this invention. Additionally, a variety of changes can be made to the present invention within the claims thereof, and embodiments obtained by combining technical means disclosed in different embodiments, as appropriate, are also within the technical scope of the present invention. Configurations including elements that are described in the foregoing embodiments, in which elements achieving similar advantages are interchanged, are also encompassed by the present invention.

INDUSTRIAL APPLICABILITY

The present invention is suitable for a mobile station device, a base station device, a communication method, a wireless communication system, and an integrated circuit.

DESCRIPTION OF REFERENCE NUMERALS

100 base station
101 data control unit
102 transmit data modulation unit
103 radio unit
104 scheduling unit
105 channel estimation unit
106 received data demodulation unit
107 data extraction unit
108 higher layer
109 antenna
200 terminal
201 data control unit
202 transmit data modulation unit
203 radio unit
204 scheduling unit
205 channel estimation unit
206 received data demodulation unit
207 data extraction unit
208 higher layer
209 antenna
301 primary base station
302 secondary base station
303, **304** terminal
305, **306**, **307**, **308** uplink

The invention claimed is:

1. A terminal device comprising:

scheduling circuitry configured to generate a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift; and

transmitting circuitry configured to transmit, to a base station device, the demodulation reference signal, wherein

the sequence group number is given by a first parameter, a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being given by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on the PDCCH.

2. The terminal device according to claim **1**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

3. The terminal device according to claim **1**, wherein

the transmission of the physical uplink shared channel that corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached is used for indicating a retransmission of a transport block in a random access procedure.

4. A base station device comprising:

receiving circuitry configured to receive, from a terminal device, a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift and

demodulating circuitry configured to demodulate the physical uplink shared channel based on the demodulation reference signal, wherein

the sequence group number is given by a first parameter, a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being transmitted on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being given by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC Parity bits scrambled by the temporary C-RNTI are attached being transmitted on the PDCCH.

5. The base station device according to claim **4**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

6. The base station device according to claim **4**, wherein

the transmission of the physical uplink shared channel that corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached is used for indicating a retransmission of a transport block in a random access procedure.

7. A communication method of a terminal device comprising:

transmitting, to a base station device, a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift, the sequence group number being given by a first parameter, wherein

a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being given by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on the PDCCH.

8. The communication method according to claim **7**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

9. A communication method of a base station device comprising:

receiving, from a terminal device, a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift, the sequence group number being given by a first parameter, wherein

a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being transmitted on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being given by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being transmitted on the PDCCH.

10. The communication method according to claim **9**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

11. An integrated circuit device mountable on a terminal device, the integrated circuit device comprising:

a scheduling circuit configured to generate a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift; and

a transmitting circuit configured to transmit, to a base station device, the demodulation reference signal, wherein

the sequence group number is given by a first parameter, a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being given by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being received on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being received on the PDCCH.

12. The integrated circuit according to claim **11**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

13. An integrated circuit device mountable on a base station device, the integrated circuit device comprising:

a receiving circuit configured to receive, from a terminal device, a demodulation reference signal associated with transmission of a physical uplink shared channel, a demodulation reference signal sequence of the demodulation reference signal being given by a sequence group number and by a value of a cyclic shift; and

a demodulating circuit configured to demodulate the physical uplink shared channel based on the demodulation reference signal, wherein

the sequence group number being given by a first parameter, a value of the first parameter is given by a value of first information configured by a higher layer in a case that the value of the first information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to downlink control information to which Cyclic Redundancy Check (CRC) parity bits scrambled by a Cell-Radio Network Temporary Identifier (C-RNTI) are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on an Enhanced-Physical Downlink Control CHannel (E-PDCCH),

a value of the first parameter is given by a physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to downlink control information to which CRC parity bits scrambled by a temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being transmitted on a Physical Downlink Control CHannel (PDCCH)

the value of the cyclic shift being (liven by a second parameter, a value of the second parameter is given by the value of second information configured by the higher layer in a case that the value of the second information is configured by the higher layer and the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the C-RNTI are attached being transmitted on the E-PDCCH, and

a value of the second parameter is given by the physical layer cell identity in a case that the transmission of the physical uplink shared channel corresponds to the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached, the downlink control information to which the CRC parity bits scrambled by the temporary C-RNTI are attached being transmitted on the PDCCH.

14. The integrated circuit according to claim **13**, wherein

the demodulation reference signal sequence of the demodulation reference signal being given by a base sequence number, the base sequence number being given by the first parameter.

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